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Original Article

Effect of Eight-Week Underwater Trampoline Exercise on Postural Control, Strength, And Quality of Life in Middle-Aged Women

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ABSTRACT

Background: The effects of aquatic exercises on strength and balance are still controversial, nevertheless an attempt has been made to investigate the effect of underwater trampoline exercise, in comparison with traditional aquatic exercise, on strength, balance, and quality of life in middle-aged women
Methods: A total of 26 middle-aged women participated in this study. The participants were randomly allocated into two groups, i.e. underwater trampoline exercise (age: 44.8±10.3yr, height: 1.62±0.6 m, weight: 76.2±8.6 kg) and traditional aquatic exercise (age: 45.7±8.8yr, height: 1.58±0.5 m, weight: 71.8±8.8 kg), using a matching method. Static balance (by stork test), strength (by dynamometer), and quality of life (by SF 36 questionnaire) data were collected before and after applying an 8-week exercise regime (three sessions per week, each session of 30–45 minutes duration). Finally, the data was analyzed by repeated measures ANOVA using SPSS software (Version 21) ($P<0.05$).
Results: The data analysis showed a significant interaction ($P<0.05$) in regard to higher mean value of criteria in the underwater trampoline group, however the values of hamstring strength and quality of life between the two groups were not significantly different.
Conclusion: The current study showed that underwater trampoline exercises can well affect the balance and strength of the users. The underwater trampoline group showed better progress in terms of the mentioned criteria. Therefore, it can be concluded that the underwater trampoline device can create a unique aquatic environment for enhanced therapeutic treatment and musculoskeletal rehabilitation.

Introduction

There exists scarce evidence of the effectivity of aquatic exercise in improving musculoskeletal form and physical function; however, although the most effective type of exercise is still uncertain, aquatic therapy is used as a form of alternative physical exercise, as is seen with resistance exercises of hydrotherapeutic programs for people with musculoskeletal problems. The properties of water, i.e. hydrostatic and hydrodynamic principles of buoyancy and drag, provide unique opportunities for musculoskeletal rehabilitation [1]. The most beneficial feature of aquatic exercise is that it offloads body weight, thus decreasing the pressure and load on the limbs and assisting to manage pain in the trunk and limbs. Moreover, the warm water can decrease swelling and pain as well as reduce muscle spasms in the body. These water properties may allow people with pain, edema, and weakness in the legs, or other limiting comorbid conditions to exercise effectively, which otherwise may

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not have been feasible through land-based exercise. Apart from the drag force that creates assistance for movement or resistance for muscle strengthening, there are additional physiological benefits of immersion for cardiopulmonary exercise related to hydrostatic pressure creating central hypervolemia [2].

Aquatic exercise, like other exercises, is based on four principles of training including exercise frequency, intensity, type, and exercise time. Specifically, the principles of overload, adaptability, advancement, reversibility, and diversity are noteworthy and should be incorporated in aquatic exercises. The overload principle is considered one of the most important controversial principles of exercise in aquatic therapy [3]. Since water resistance and body weight are steady in these exercises, we need auxiliary tools for application of overloading in water [4]; water dumbbell, step system, spinning, and water treadmill are some of the assistive tools for creating overload and diversity in aquatic exercise.

Although many studies have investigated the effectiveness of aquatic exercise on strength-building, no consensus has been reached regarding its efficacy of improving strength in musculoskeletal conditions. For this reason, additional auxiliary tools such as special weights were used as part of the water exercises to enhance functional performance [5]. Another benefit of water-based exercise is that it affords a reduced risk of fall, i.e. water is a safe training environment particularly for people who are more likely to fall. This reduction in the risk of falling can reduce the effect of aquatic exercises on balance [6]. Therefore, it is essential to use tools that challenge balance in water, and in this regard, the trampoline is one of the best training tools for improving balance.

The various benefits of trampoline exercise include improving muscle strength, improving flexibility, improving muscular system, increasing bone density, increasing key hormones (testosterone, growth hormone, serotonin), relaxing the body, lowering cortisol hormone (stress hormones), increasing coordination and body balance, decreasing fatigue, increasing self-confidence, and enhancing learning ability [7]. The evidence of these benefits have been established in a non-aqueous environment. In professional aquatic exercise centers, the underwater trampoline has been used for many purposes. The literature, however, does not show evidence as to the physical and mental effects of using the trampoline underwater. The effects of aquatic exercises on strength, balance, etc., are still controversial, but the researcher has attempted to investigate the effects of underwater trampoline exercises vis-a-vis traditional aquatic exercises on strength, balance, and quality of life in middle-aged women.

Methods

This study was conducted using a sample of 26 middle-aged women, randomly assigned into two groups: underwater trampoline exercise and traditional aquatic exercise. At $\alpha=0.05$ and $\beta=0.2$, and because of the large effect size (0.8 and above), a sample size of 15 was considered in each group to obtain a statistical power of 0.8, which is suitable for empirical studies [8]. Table 1 shows the characteristics of the participants for this study. The study was approved by the Research Council of Azad University of Isfahan and all the participants gave their written consent for their data to be used in the research.

Inclusion criteria include: Participants aged 40–55 years old, clients of Pars health center and Shahin pool, non-regular exercisers, having non-acute or chronic physical conditions such as skin, cardio, respiratory, liver, and musculoskeletal disorders. Exclusion criteria include absenteeism in more than one-third of exercise sessions, did not participate in pre or posttest, and reluctance to continue in the study. According to these criteria, 26 out of 30 participants completed the study and the final statistical analysis was performed on these subjects. Data was collected in two stages: before and after the intervention. Prior to the interventions, the suitability of subjects to participate in the exercise programs was approved by a specialist physician.

The stork test was used to evaluate static balance [9]. Each subject was asked to remove their shoes and place their hands on their hips, and then position the non-supporting foot against the inside knee of the supporting leg. The subject was given one minute to practice the balance. The subject had to raise their heel to balance on the ball of the foot. The stopwatch was started as soon as the heel was raised off the floor. The stopwatch was stopped if any of the following occurred: The hand(s) come off the hips, the supporting foot swivels or moves (hops) in any direction, the non-supporting foot loses contact with the knee, or the heel of the supporting foot touches the floor.

The Commander Strength track hand-held dynamometer (trademark of JTECH, USA) was used to measure muscle strength as per the instrument manual [10]. To measure the strength of the quadriceps muscles, the subject sits on the bed and the examiner places the console of the device as fitted to the leg (shown in Figure 1) to measure the strength of the muscle. To measure the strength of

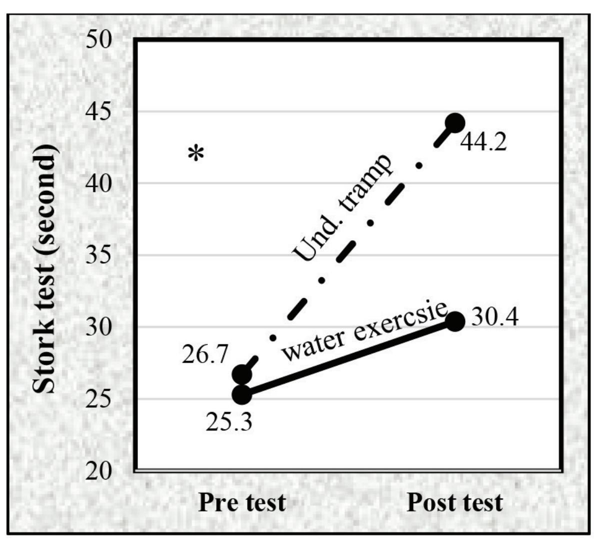

Figure 1: Chart line of static balance

Table 1: Participant demographics data [mean±standard deviation]

	Underwater tramp [N=13]	Water exercise [N=13]	sig
Age [year]	44.8±10.3	45.7±8.8	0.6
Weight[kg]	76.2±8.4	71.8±8.8	0.71
Height [m]	1.62±0.68	1.58±0.58	0.64

hamstring and abductor muscles, the individual lies on the stomach and on side, respectively. It should be noted that the strength of each muscle member was measured three times, and the average of three repetitions was considered as the final record.

The SF 36 questionnaire was used to assess the quality of life. This questionnaire is used as a means for measuring the general health as related to the quality of life. The questionnaire contains 36 questions for eight dimensions [11], with a total score ranging from 0–100, higher the scores higher the health status and vice versa. The scores of this questionnaire can be divided into two dimensions of physical and mental. The validity and reliability of this questionnaire has been proved in numerous studies, and its Persian version is also available with acceptable validity (r=0.9) and reliability (r≥0.77 in different dimension) [12].

In order to implement the exercise protocol for the underwater trampoline group, a trampoline of suitable size and dimensions was designed and constructed such that it could be used in the pool. The exercise protocol of the traditional aquatic exercise group was based on standard methods available for this field. The two groups' exercise programs were designed and supervised by the researchers. The selection of exercise program for each session was based on the ability levels of participants.

Exercise programs include: single and double leg bouncing, upper limb workout in single-leg position, step-training, jogging, liftoff in different positions, lift-off just by core torso muscle push-down, running in place, alternate feet shuffle, feet twist, holding, slapping, breathwork bouncing, pulse pace bouncing, frequent flower, jumping jacks, and kangaroo jumps [13].

All the analyses were performed using IBM SPSS (Version 21.0, SPSS Inc., Chicago IL, USA). The normal distribution of parameters was evaluated by the Shapiro–Wilk test. The data was analyzed by repeated measures analysis of variance [RMANOVA]. All statistical tests were two-tailed with an alpha level of less than 0.05 ($P \leq 0.05$).

Results

The participants' demographic characteristics are shown in Table 1. As seen from this table, the difference between the two experimental groups in terms of demographic information was not statistically significant ($P > 0.05$), and so in this regard the two groups were completely homogeneous.

The results of RMANOV are shown in Table 2. The most important part of the variance analysis test for repetitive data is interaction. This part of the test represents the changes within the groups as compared to each other. As shown in Table 2, in all variables except for the strength of hamstring muscles and quality of life, interaction was significant ($P<0.05$). With regard to the higher mean value of criteria in the underwater trampoline group, it can be concluded that the underwater trampoline group showed more progress for the mentioned criteria. On the other hand, the contrast in quality of life dimensions among participants was significant and confirmed the effectiveness of the two-group program for this criteria. Detailed comparisons are illustrated in Figures 1–5, which demonstrate that, in assessing balance, and abductors and quadriceps muscle strength, the control group showed no

Table 2: Descriptive statistics of variables and result of repeated measures analysis of variance

Criteria	Group	Pre test Mean±SD	Post test Mean±SD	Between subjects contrast	Within subjects contrast	Group Interaction
Stork test (second)	Underwater tramp	26.7±8.6	44.2±9.6	F=0.6	F=12.1	F=47.7
	Water exercise	25.3±7.7	30.4±5.7	P=0.44	P=0.03*	P=0.001*
Right quadriceps(N)	Underwater tramp	87.1±14.6	143.8±12.6	F=2.7	F=47.2	F=19.7
	Water exercise	78.5±10.7	100.7±16.7	P=0.11	P=0.001*	P=0.017*
Left quadriceps(N)	Underwater tramp	79.9±13.4	140.7±12.3	F=1.6	F=38.1	F=17.1
	Water exercise	67.8±9.6	95.5±11.8	P=0.2	P=0.001*	P=0.02*
Right hamstring(N)	Underwater tramp	78.2±15.6	99.8±17.6	F=2.3	F=28.8	F=5.7
	Water exercise	67.0±12.7	85.1±11.7	P=0.12	P=0.001*	P=0.06
Left hamstring	Underwater tramp	68.1±11.6	90.2±13.6	F=4.9	F=30.0	F=4.9
	Water exercise	60.6±10.7	81.1±9.7	P=0.4	P=0.001*	P=0.05
Right Abductors(N)	Underwater tramp	59.3±9.6	127.2±12.6	F=1.7	F=63.0	F=9.6
	Water exercise	51.7±10.7	94.1±9.7	P=0.1	P=0.001*	P=0.03*
Left Abductors(N)	Underwater tramp	52.1±11.6	92.8±11.1	F=3.4	F=46.5	F=8.9
	Water exercise	45.8±10.7	87.4±10.9	P=0.08	P=0.001*	P=0.04*
QOL mental	Underwater tramp	55.7±1.6	69.9±1.8	F=3.2	F=39.3	F=1.4
	Water exercise	43.8±0.9	63.1±1.3	P=0.055	P=0.001*	P=0.24
QOL physical	Underwater tramp	31.4±11.2	53.9±13.7	F=2.3	F=41.1	F=0.31
	Water exercise	44. 1±10.1	66.4±9.8	P=0.14	P=0.005*	P=0.58

N=new to

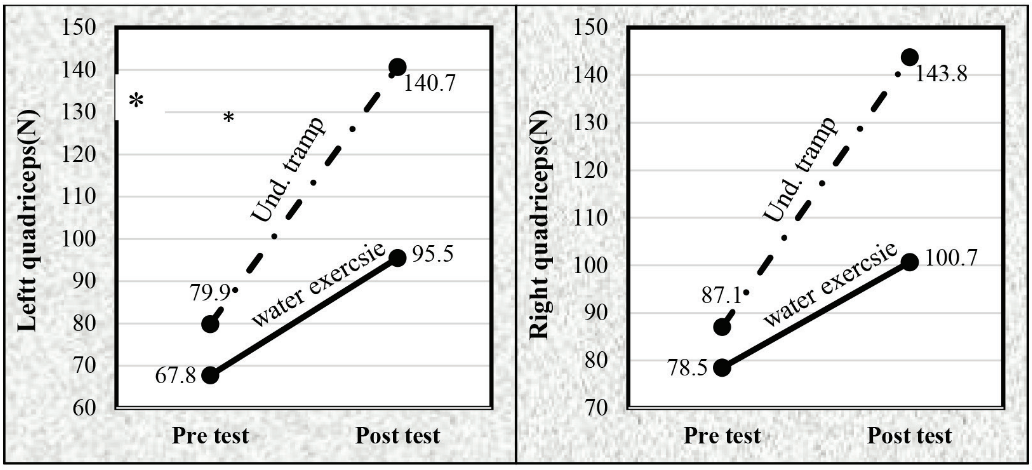

Figure 2: Chart line of quadriceps strength

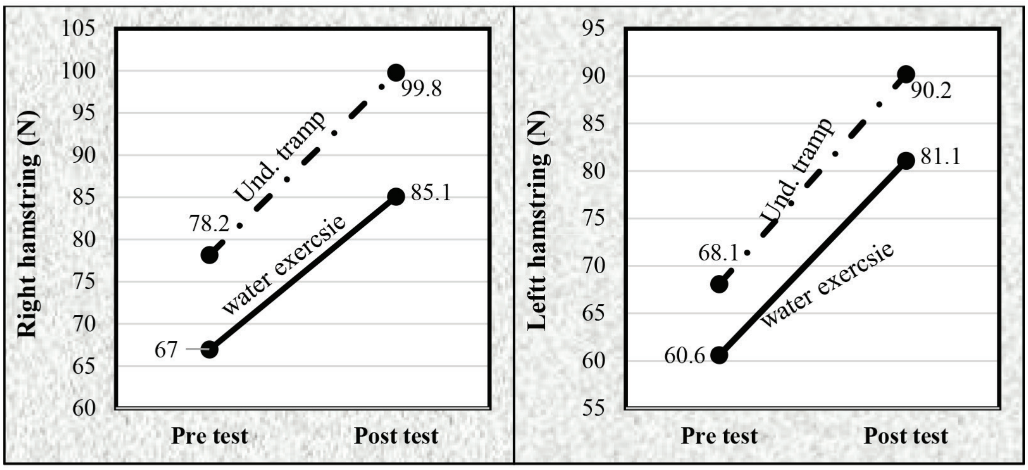

Figure 3: Chart line of hamstring strength

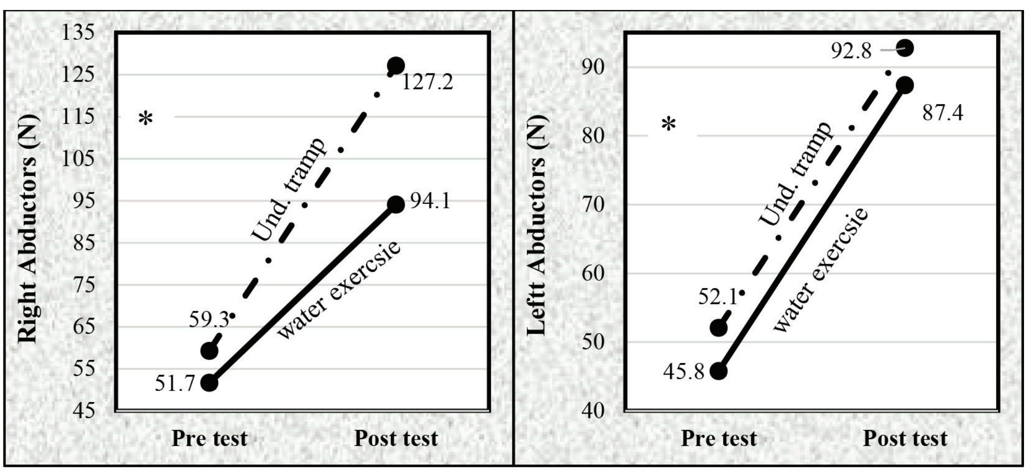

Figure 4: Chart line of Abductors strength

progress, while in comparison the experimental group made significant improvements.

Discussion

Exercising in an aquatic environment has always had a unique and specific impact, because of the characteristics of water. In addition to the psychological and emotional properties that positively affect humans, water has hydrostatic and hydrodynamic properties that influence various physical fitness factors such as cardiovascular fitness, strength, flexibility, balance, and muscular endurance. Moreover, aquatic exercise has a positive effect on postural alignment and daily activities, and can be used as a rehabilitation method to treat many musculoskeletal problems [14]. A range of assistive aids such as special weights, boards, spinning, etc., are incorporated for use in aquatic exercises to create variety and overload. However, among these tools there are very few that can impact balance abilities [2]. One of the most well-known balance training tools is the trampoline, which can be used underwater too. Therefore, the aim

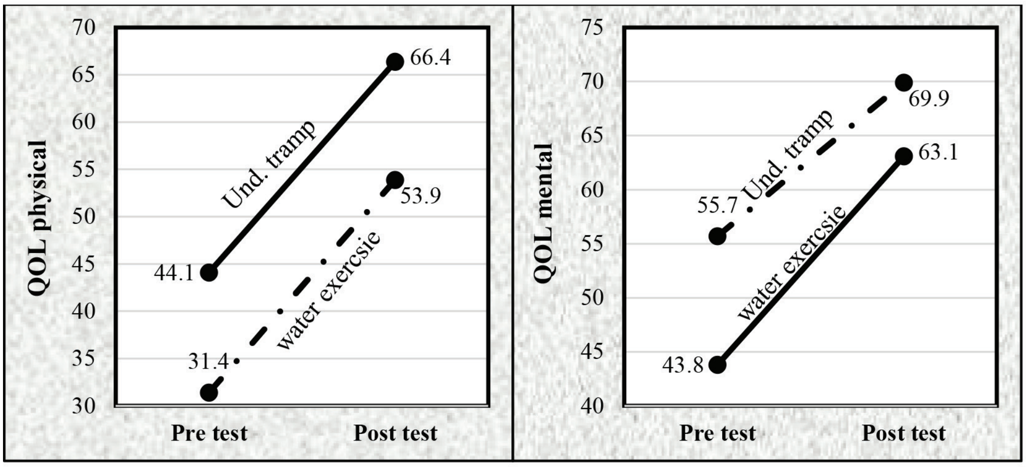

Figure 5: Chart line of quality of life

of this study was to investigate the effect of underwater trampoline exercises on balance, strength, and quality of life of non-athletic middle-aged women. The results showed the superiority of the underwater trampoline group compared to traditional aquatic exercise group for all variables, except for the variable of hamstring muscle strength.

In regard to the static balance variable, there was a 65% improvement made by the underwater trampoline group, while the aquatic exercise group improved by 20%. In this test, the ability of a person to stand on a single leg is measured; while doing this, the muscles of the lower limb play a vital and effective role, and because of the static nature of the test, causes engagement of the anti-gravity muscle. The quadriceps, hamstrings, gluteus maximus, gastrocnemius, and soleus are part the muscle group that can be effectively examined in the stork test. Considering that jumping and landing (which is the main component of underwater trampoline exercises) play a positive role in engaging all these muscles, it seems that the improvement of static balance is due to strengthening of the abovementioned muscles [15].

Balance refers to the ability to control the center of gravity of a body, which depends largely on the physical and nervous components as well as the center of consciousness in the brain. Furthermore, balance is one of the main components of bodily movements [16], hence it is essential not only to the development of movement skills but also for the learning of complex and coordinated movement skills [17]. Static balance refers to the ability of a body to maintain the line of gravity when it is motionless [16]. In static balance, the main component of which is standing, five important elements are required: 1) sufficient strength in the lower limb muscles; 2) postural sensitivity to transmit information of posture; 3) ability of the inner ear to send appropriate impulses about the posture; 4) the central coordination that is mainly in the cerebellum; and 5) the activity of higher centers associated with postural control [18].

Previous research has studied the physiological mechanisms of improving balance with a trampoline as a rugged and unstable surface, and results have shown that it can lead to balance improvement. On the other hand, trampoline exercises are performed in the standing position, which causes more muscle involvement in the body and improves the balance [19]. Therefore, these significant and positive effects of trampoline exercises for improving balance are acceptable and not far from expected.

Another important result of the present study was the effect of underwater trampoline exercises on muscle strength of the quadriceps and abductor muscles. One of the main reasons for this improvement is the movement of climbing onto the trampoline and jumping on the device. The quadriceps and hip abductor muscles form part of the most important muscle group involved in jumping movements [20]. Due to the drag force of water, the pressure on these muscles is much higher, resulting in improved strengthening. On the other hand, traditional exercise has less jump movements. This explains why underwater trampoline exercises are considered superior in terms of improving muscle strength of the quadriceps and abductors. In general, the nature of the trampoline causes a shaking effect on the muscle spindles, thus improving muscle tone. With increased tone the length and elasticity of muscle fibers is also increased, and in muscles with reduced tone it increases the contractility of muscle fibers [21]. Enhancement of muscle tone can improve muscle strength.

As shown by the data in Table 2, the group interaction in regard to the two dimensions of mental and physical quality of life variable was not significant, which means that neither of the two groups were superior to the other. On the other hand, the results of the table showed that among the subjects significant contrast of change was observed in both dimensions. In other words, both exercise techniques have positive effects on the quality of life as shown by data analysis: mental dimension improved by 22.5 units and 22.3 units in underwater trampoline and aquatic exercise groups, respectively, and the variable of physical dimensions improved by 14.9 units and 19.3 units in the of underwater trampoline and aquatic exercise groups, respectively. Although there is no unique definition of quality of life, a feeling of wellbeing can be perceived as a clear indication of quality of life, and is the most important dimension sought by man to be promoted. What is important about quality of life is the close connection between this concept and other related concepts such as wellbeing, health status, satisfaction in life, and hope [22]. On the other hand, the quality of life involves the two important dimensions of physical and mental health. Due to properties that affect the various factors of physical fitness, exercise will always have a positive impact on quality of life in this dimension. This effect is greatly enhanced by the high resistance of water environment in regard to aquatic exercises [23]. Since these exercise were conducted group-wise, the improvement of social relationships and promotion of quality of life from this perspective seems natural. Then again, the property of water to create calm in humans could also be one of the main reasons for improving the quality of life in the two groups.

Conclusion

The current study showed that underwater trampoline exercises can enhance the balance and strength of users. These two factors, as the most significant health factors, are less impacted in traditional aquatic exercises. Therefore, incorporating underwater trampoline exercises can convert the aquatic environment into a unique setting for therapeutic treatment and musculoskeletal rehabilitation.

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Conflict of interest: None declared.

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